

Diagnostic Techniques and Treatments for Internal Disorders of Koi (*Cyprinus carpio*)

Nicholas Saint-Erne, DVM

KEYWORDS

- Fish • Carp • Koi • Diagnosis • Reproduction
- Internal medicine

Aquatic veterinary medicine is a fast-growing field in veterinary medicine, and aquatic veterinarians are involved in food fish production (aquaculture), natural fisheries management, research using fish as models, public aquarium maintenance, and ornamental fish keeping. The AquaVetMed.info Web site lists more than 700 veterinarians as practicing aquatic veterinary medicine. There are several worldwide organizations for veterinarians whose medical practice includes fish; including the World Aquatic Veterinary Medical Association (www.WAVMA.org) and the International Association for Aquatic Animal Medicine (www.IAAAM.org). The American Veterinary Medical Association (www.AVMA.org) survey of United States households' pet ownership, which is conducted every 5 years, indicates that in 2006 there were more than 9 million American households keeping a total of more than 75 million pet fish.¹ These numbers are 50% greater than in the previous 2001 AVMA survey!

Nishikigoi (Japanese for "brocaded carp"), or koi for short, are colorful variations of the common carp (*Cyprinus carpio*) that have been selectively bred in Japan for more than 200 years. In the last 50 years they have become very popular worldwide as ornamental fish. Koi can grow quite large (up to 100 cm) and live for many decades. Individual koi fish with perfect color patterns are valuable (**Fig. 1**). There are koi shows held all over the world, and a show-quality koi can be worth thousands, even tens of thousands of dollars. For this reason, along with their longevity and endearing personalities, koi are one of the fish species most often presented to the veterinarian for treatment of diseases.

Aquatics Division, PetSmart, Inc, 19601 North 27th Avenue, Phoenix, AZ 85027, USA
E-mail address: nsainterne@ssg.petsmart.com

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Fig. 1. A Tancho Goshiki (red circle on head of black patterned koi) that recently sold for well in excess of \$10,000. (Courtesy of Pan Intercorp, Kenmore, Washington. www.Koi.com.)

DIAGNOSTIC TECHNIQUES

Disease diagnosis and treatment of koi or other ornamental fish in the veterinary hospital use techniques similar to those used for other animal species. Most of the needed equipment is already in the small animal veterinary hospital, except for water containers and filtration systems. One of the most important diagnostic tools is taking the history of the patient.² Discussing the patient's history with the owner is as necessary with fish as it is with other pets. History taking includes obtaining information on age, origin, length of ownership, previous diseases and treatments, feeding habits, aquatic habitat, water quality, and filtration systems. As with many exotic pets, knowing the environmental information is helpful in making an accurate diagnosis.

Many common clinical techniques can be used to diagnose diseases of koi, and these have been described in many other publications.²⁻⁷ Diagnostic tests for external disorders are inexpensive, and can be performed using standard veterinary techniques.⁶ Common diagnostic tests include skin, fin, and gill biopsies examined microscopically for diagnosing external parasites, culture and sensitivity testing for bacteria, polymerase chain reaction (PCR) tests for viruses, blood chemistry and serology, tissue and fluid aspiration cytology, radiology, and sonography. More advanced techniques available through specialty practices or veterinary colleges such as magnetic resonance imaging (MRI) and computed tomography (CT) are used for koi as well.

When handling fish for clinical procedures or diagnostic tests, the veterinarian and assistant should wear wet latex gloves to prevent damage to the fish's scales, skin,

and glycocalyx (the mucus layer that protects the epidermis). Koi can be kept out of the water during examination, provided that the skin and gills are kept moist. Small fish (<20 cm in length) can be maintained out of the water for 5 to 15 minutes, larger fish for as long as 30 minutes or more, keeping in mind their health condition and monitoring their respiration. Use a wet towel or chamois cloth to lay the fish on and to wrap around it during handling.⁷ Add dechlorinated water as needed to keep the koi wet. Cover the koi's eyes with a wet cloth to reduce light, and limit noise and vibrations around the area to help keep the fish calm while being examined.⁸ The holding tank for the koi while in the clinic can also be opaque to reduce light and to prevent the fish from a sudden burst of motion if visually startled, resulting in injury from hitting the sides of the enclosure. The holding tank should be covered to prevent the fish from jumping out of the container. Use an aquarium water quality test kit to ensure that the holding tank water is ideal for keeping koi. The water should be kept aerated using an electric air pump or oxygen canister connected with plastic tubing to an air stone, producing fine bubbles in the water. **Table 1** lists the water quality tests and ranges appropriate for the holding tank water quality.⁹

Anesthesia techniques in fish are well described in a variety of publications.^{7,10–12} Anesthetics can be useful with large koi to keep them still during examination and imaging, and to prevent injury during handling. Currently the US Food and Drug Administration has approved tricaine methanesulfonate powder, commonly called MS-222 (Finquel; Tricaine-S), as an anesthetic for fish. A buffered solution of MS-222 can be added to the water containing the fish at a dose of 30 to 40 mg/L to sedate koi for handling and examination, and a higher dose of 50 to 150 mg/L is used for anesthesia. Induction is fairly rapid, within 5 minutes, but recovery once the fish is placed into fresh water is dependent on how long the fish has been exposed to the anesthetic solution. Short-term anesthesia will have recovery times of 5 to 10 minutes, but long-term anesthesia, such as with surgical procedures, may result in prolonged anesthesia recovery times of 30 to 60 minutes. Isoeugenol (Aqui-S) is an investigational new animal drug, and works well as a fish tranquilizer to aid in handling koi. It is used at a dose of 30 to 60 mg/L and sedation occurs within 5 minutes, with a similar recovery time once the koi is placed in fresh water. The recovery water must be of appropriate temperature and be aerated with an air pump or with oxygen bubbled through the water. Use of an electrocardiogram or Doppler flow probe to measure the heart rate

Table 1
Water quality parameters

Water Test (Unit)	Optimal	Acceptable Range
Temperature (°F)	65	60–80 (will survive 39–95)
Dissolved Oxygen (mg/L)	9	6–12
Ammonia (mg/L)	0	0–0.02
Nitrite (mg/L)	0	0–0.02
Nitrate (mg/L)	0	0–40
pH (-Log[H ⁺])	7.2	6.2–8.5
Hardness (mg/L)	100	75–250
Alkalinity (mg/L)	100	75–250
Salinity (%)	0.1	0–0.3
Chlorine (mg/L)	0	0–0.02

Data from Saint-Erne N. Water quality in the koi pond. In: Advanced koi care. Glendale (AZ): Erne Enterprises; 2002. p. 108.

and a pulse oximeter clipped onto the caudal fin to monitor blood oxygen saturation will help monitor patient status and depth of anesthesia.⁷ Opercular motion (breaths) should also be observed and recorded during anesthesia and recovery. If opercular motion ceases during anesthesia, the depth of anesthesia may be excessive.

Radiographs can be taken successfully with standard veterinary radiology equipment.^{3,6,7,13} In most cases, radiographs can be taken of koi without anesthesia by briefly restraining them in a sealed plastic bag with a small volume of water (**Fig. 2A, B**). The koi in the plastic bag can be placed directly onto the film plate or digital sensor, and the bag taped down if necessary to hold the fish in the correct position. Anesthetized koi can be briefly taken out of the water and positioned for radiographs (see **Fig. 2C**). Foam rubber supports are used if necessary to maintain the position of the koi. Radiographs are helpful in diagnosing gas bladder (swim bladder) abnormalities, spinal deformities, abdominal masses, and occasionally ingested foreign objects.¹⁴ Normal radiographic anatomy can be seen in **Fig. 3A, B**. Abdominal viscera are not easily distinguishable in a radiograph. A flexible rubber tube can be inserted orally to place barium or iodinated contrast medium into the intestines (koi do not have stomachs) to perform contrast studies (**Fig. 4**) on the koi intestinal tract.¹⁵ The dosage for barium is 5 to 10 mL/kg body weight and the iodinated medium is dosed at 1 to 2 mL/kg. Care must be taken not to leak barium into the oral cavity and onto the gills, which could impair oxygen diffusion through the gills.¹⁶

Ultrasound has been used on fish for sex determination for nearly 30 years.^{17–19} Ultrasound imaging is easy with fish confined in a small container of water, as the

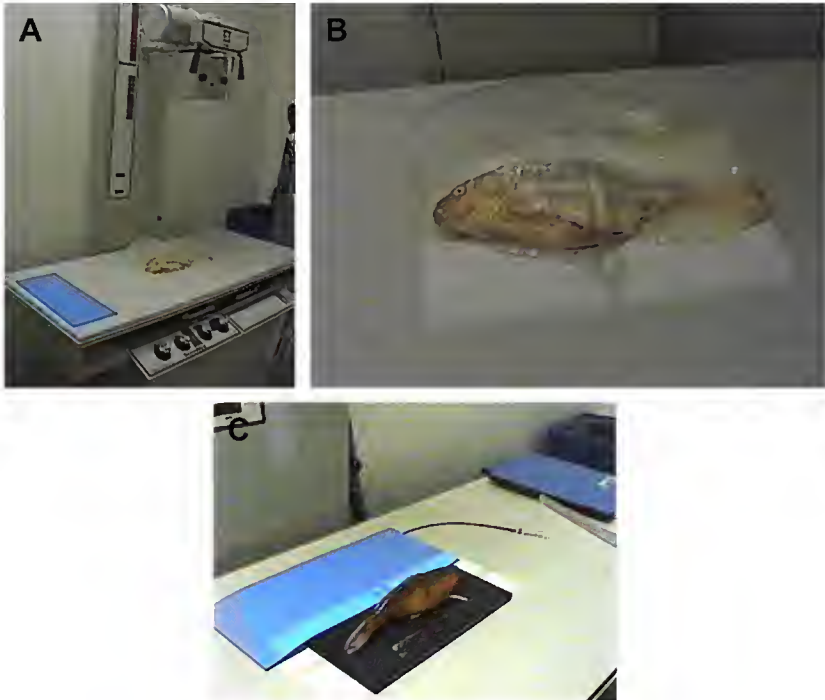


Fig. 2. (A) X-ray machine with koi restrained in plastic bag of water on tabletop for radiograph. (B) X-ray machine with koi in plastic bag with water on tabletop for radiograph. (C) Anesthetized koi positioned without restraint for radiographs. (From Saint-Erne N. Clinical procedures. In: Advanced koi care. Glendale, AZ: Erne Enterprises; 2002. p. 47–8; with permission.)

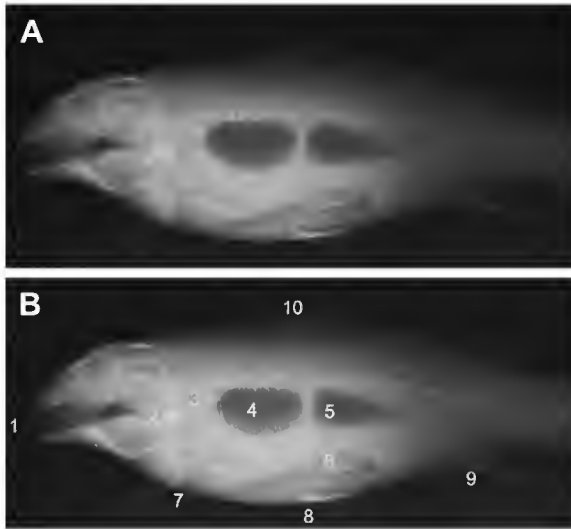


Fig. 3. (A) Normal koi radiograph. (B) Normal koi radiograph with anatomy labeled. 1, mouth opening; 2, pharyngeal teeth; 3, Weber's ossicles connecting the gas bladder to the inner ear; 4, cranial chamber of the gas bladder; 5, caudal chamber of the gas bladder; 6, gas in a loop of intestines; 7, pectoral fin; 8, pelvic fin; 9, anal fin; 10, dorsal fin. (Modified from Saint-Erne N. Clinical procedures. In: *Advanced koi care*. Glendale (AZ): Erne Enterprises; 2002. p. 36; with permission.)

water serves to couple the transducer to the fish's body, eliminating the need for ultrasound gel.³ Transducers of 5 to 10 MHz work well for visualization of internal organs at depths up to 13 to 20 cm into the body, with lower frequency transducers producing images at greater depths of tissue penetration. If not waterproof, the transducer can be placed inside a plastic cover (eg, plastic bag, examination glove, condom) for protection. The transducer can be held several centimeters away from the koi if it is in the water, and the transducer repositioned until the desired image is obtained. Motion imaging can be used for guided tissue biopsy collection, abdominocentesis (Fig. 5), or to insert needles for aspiration of the gas bladder.⁷ Anesthesia may be needed for biopsy sample collection. Echocardiography is helpful in assessing heart

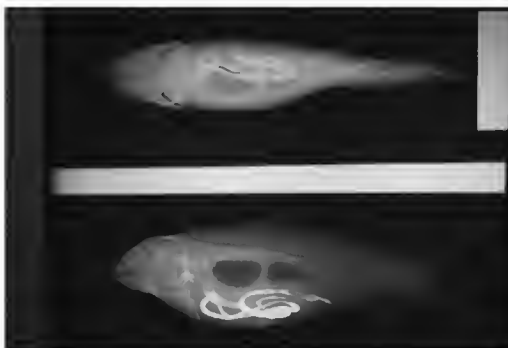


Fig. 4. Koi radiograph with intestinal barium (3 hours post administration). (Top) Dorsal-ventral view. (Bottom) Lateral view. (From Saint-Erne N. Clinical procedures. In: *Advanced koi care*. Glendale (AZ): Erne Enterprises; 2002. p. 48; with permission.)



Fig. 5. Using ultrasonography to guide an abdominocentesis. (Courtesy of Gregory A. Lewbart, MS, VMD, Dipl ACZM, North Carolina State University College of Veterinary Medicine, Raleigh, NC, USA.)

rate during anesthesia.¹⁶ The 2 chambers of a koi's gas bladder are highly visible using ultrasonography, as the contained air reflects back a white image. A deflated or fluid-filled chamber of the gas bladder can also be detected using ultrasonography. If the gas bladder contains water, it will transmit the sound waves and appear black.

Endoscopy can be used in tranquilized koi to examine the oral cavity, gill arches, and the pharynx. Flexible endoscopes can be passed through the esophagus into the intestines.⁷ Koi have no stomach, but the proximal intestine is elastic and can distend to hold ingesta. The distal intestines are smaller in diameter. The koi's intestinal tract loops back and forth in the coelomic cavity, and is approximately 3 times the length of the body. Laparoscopy (coelioscopy) can be performed in year-old (~8 in [20 cm]) or larger koi to visualize internal organs or take biopsy samples. A small surgical incision can be made through an anesthetized koi's body wall to insert an endoscope. Coelomic cavity visualization is used to evaluate the liver (hepatopancreas), the gonads to determine gender or reproductive organ development,²⁰ the presence of adhesions or inflammation, the gas bladder position and status (inflamed, deflated, or fluid infused), or to conduct a tissue biopsy or collect an abdominal swab for bacterial culture. If the coelomic cavity has been insufflated with air during the procedure, the air must be removed to prevent buoyancy problems immediately after the procedure. The small incision can be closed with a simple interrupted absorbable suture, or sealed with methacrylate tissue adhesive.²¹

Surgery to expose the coelomic cavity in koi is performed through a ventral midline incision. The fish is positioned in dorsal recumbency on a foam block with a v-shaped notch, or on rolled wet towels.^{21–23} Various surgical tables and platforms have been designed (**Fig. 6**) to aid in anesthetic administration during fish surgery.^{22–27} Some surgeons remove scales in the operating area before cutting the skin; others cut through the scales (which can be more difficult in large koi) but then only remove the scales that are actually damaged during the surgery, reducing the number of scales that ultimately are removed. Scales will eventually regrow in most cases. Intra-coelomic surgery is performed in the management of many disorders, including intestinal foreign body removal, tumor removal, elective gonadectomies, reproductive disorder treatments, gas bladder abnormalities and buoyancy problems, diagnostic exploration, and organ biopsy.²³ Gonadal neoplasms are encountered in mature koi, both male and female (**Fig. 7**). Such neoplasms can be surgically excised, with

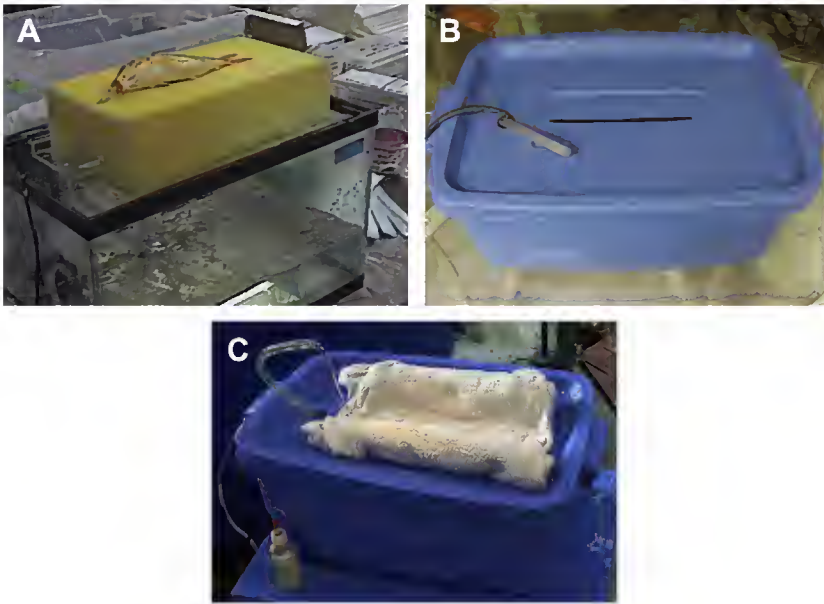


Fig. 6. (A) Anesthesia delivering surgical table for fish developed by Craig Harms and Greg Lewbart, North Carolina State University. (B) Portable surgical platform with anesthesia delivery. Water recirculates through slit in plastic lid down into container. Pump in container pushes water up through tube to koi. (C) Portable anesthesia delivering surgical platform showing water flowing from tube that can be inserted into the koi's mouth, and wet towels rolled to hold koi in position. (From Saint-Erne N. Clinical procedures. In: Advanced koi care. Glendale (AZ): Erne Enterprises; 2002. p. 51–2; with permission.)

great benefit if surgery is performed before significant damage has been done to the abdominal organs.^{22,28}

Monitoring of the fish's condition while anesthetized during surgery can be accomplished by using electrocardiography (ECG). Hypodermic needles are inserted into the musculature of the koi at the base of the pectoral fins and near the anus (or vent) while the koi is out of the water in dorsal recumbency for surgery.^{3,7} The metal clips of the

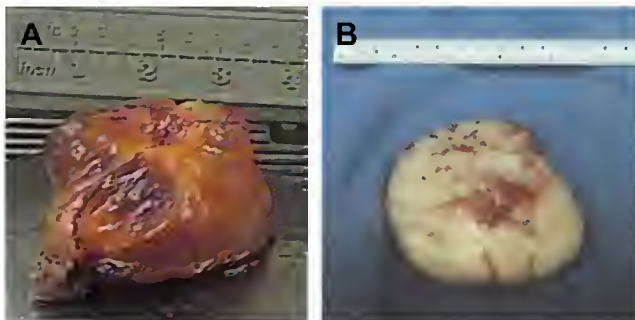


Fig. 7. (A and B) Surgically removed ovarian and testicular gonadal sarcomas. Note that tumor sizes range from 3 to 4 inches (7.5–10 cm) in diameter. (From Saint-Erne N. Neoplasia in koi. In: Advanced koi care. Glendale (AZ): Erne Enterprises; 2002. p. 136–7; with permission.)

ECG leads are attached to the metal needles (**Fig. 8**): the RA lead on the needle by the right pectoral fin, the LA lead on the needle by the left pectoral fin, and the LL lead on the needle by the vent. The P-QRS-T waves produced are of low amplitude (1 mV QRS complex), but similar to those of other animals. Heart rates are temperature dependant, as well as being affected by anesthesia. Normal heart rates for koi are 30 to 40 beats per minute (bpm), but can range from 15 to 100 bpm, and under anesthesia are 10 to 20 bpm.⁷

Closure of surgical incisions is accomplished by using absorbable monofilament suture material to close the muscle layer in a simple continuous pattern. Trapped air in the abdomen is removed by aspiration during closure. The skin is closed with monofilament nylon or absorbable sutures with a swaged-on reverse cutting needle. Simple interrupted or continuous suture patterns are used to oppose the margins of the skin incision (**Fig. 9**). In smaller fish, the muscles and skin may be closed in one layer. Skin sutures are removed in 2 to 3 weeks, or when the skin appears adequately healed.²² Postsurgical pain management can be provided as needed using butorphanol 0.05 to 0.10 mg/kg intramuscularly.

CT scans can be performed on koi while they are in a small chamber of oxygenated water.³ The water does not affect the image in a CT scan. The CT images are of narrow slices generated in the axial or transverse plane through the body that are examined sequentially to detect abnormalities. Helical CT methods scan the patient continuously, producing images with higher resolution and better 3-dimensional reconstruction (**Fig. 10**). Helical CT is also faster than standard CT scanning, so the koi is examined more quickly.¹⁶

MRI can produce very detailed images of the internal anatomy of koi.^{3,16} Unfortunately, it is mostly available only at university and specialty veterinary hospitals; it is also still an expensive diagnostic technique. Because the patient must remain motionless during the imaging, anesthesia is necessary.

COMMON INTERNAL DISEASES AND THEIR TREATMENT

Abdominal (coelomic) enlargement in koi can result from bacterial infections producing ascites (dropsy), typically by bacteria in the genera *Aeromonas* or *Pseudomonas*. Granulomas of the liver or other organs can occur from bacterial infections caused by the zoonotic *Mycobacterium*. These infections require long-term injectable



Fig. 8. Metal ECG leads clipped onto hypodermic needles inserted into pectoral musculature of a koi under anesthesia for surgery. (From Saint-Erne N. Clinical procedures. In: Advanced koi care. Glendale (AZ): Erne Enterprises; 2002. p. 55; with permission.)



Fig. 9. Simple interrupted pattern of skin closure during surgery on a koi. (From Saint-Erne N. Clinical procedures. In: Advanced koi care. Glendale (AZ): Erne Enterprises; 2002. p. 56; with permission.)

and oral antibiotic administration. Percutaneous needle aspiration of ascitic fluid, especially guided by ultrasonography, and culture with sensitivity testing can help in determining appropriate antibiotic treatment. Noninfectious causes of coelomic enlargement include obesity, egg retention, neoplasia, gas bladder abnormalities, and intestinal obstructions, which can be differentiated using many of the diagnostic techniques described in the previous section.

Digestive system abnormalities can be caused by intestinal obstruction from an ingested foreign object such as a rock, plastic plant segment, coins, or debris in the water. Radiographs, especially with contrast media, help confirm the location of the obstruction. The obstruction sometimes can be retrieved orally using a flexible endoscope with biopsy forceps. Surgical removal via enterotomy can also be successful. One potential problem is that the condition may have been present for an extended time before the diagnosis is made, making prognosis less favorable.

Obesity is also not uncommon in well-cared for koi. The owners may have a tendency to overfeed the fish to get them to come up to the surface for viewing. Normal feed quantities should be 1% to 3% of the body weight daily, and a good rule of thumb is to feed only what the fish will consume in 3 to 5 minutes, once or twice



Fig. 10. CT image of a koi skeleton taken on a live koi. (Courtesy of Gregory A. Lewbart, MS, VMD, Dipl ACZM, North Carolina State University College of Veterinary Medicine, Raleigh, NC, USA.)

daily. Overfed koi may have a distended abdomen due to accumulated abdominal fat, and may have a hump at the nape of the neck where the skull ends and the scaled dorsum begins (**Fig. 11**). Hepatic lipidosis may accompany obesity from overfeeding and may occur due to feeding high-fat (>15%–18% fat) diets.²⁹ Fatty infiltration of the liver can also occur due to biotin or choline deficiency, or toxemias. Liver biopsies can be collected for histopathology examination through a small surgical incision or through endoscopic biopsy.³⁰ With hepatic lipidosis, the liver may appear yellowish and mottled, and be greasy when cut. Fatty infiltration results in intracellular oil droplets in the cytoplasm of the hepatocytes, not just fat between the liver cells. Treatment is to reduce feed quantity and fat content of the diet, and to feed a balanced, quality koi food.

Enlarged ovaries causing abdominal distension in female koi can be diagnosed with imaging techniques such as radiography, ultrasonography, or CT imaging (**Fig. 12**). Initiation of the reproduction in koi is based on increased daylight time in the spring and warming temperatures, which stimulate the release of gonadotropin hormones. When the water temperature reaches beyond 63° to 65° F (17.5°–18.5°C), the koi start to spawn. Koi that are kept indoors or in a heated pond during the winter that do not go through the normal cool to warm water cycle may not be stimulated to spawn. Over time, unspawned eggs are normally reabsorbed in a female as egg production is at the expense of stored mesenteric fat. But in an overfed female koi, this reabsorption of the eggs may not occur, resulting in a condition known as egg binding, or roe retention, whereby a large number of mature eggs are in the ovary and are unable to be released.³¹ Eventually the distended ovaries can become necrotic, or impede normal hepatic or intestinal functions by causing a physical obstruction.

Egg binding tends to occur in overfed, fatty koi.³² Reducing feeding after the normal spawning season so that females will reabsorb any remaining eggs may prevent egg binding. As a general guideline, reduce the feeding by half for a period of several weeks if the female koi still has abdominal enlargement after the spawning season in spring, depending on water temperature and body condition. See **Fig. 13** to determine normal body weight for koi length. Providing a cool-water period before spring can also help produce a normal spawning cycle in fish that are otherwise kept in a warm pond in the winter. Ovulation can also be induced by injections of carp pituitary extract (2–5 mg/kg intramuscularly, repeat in 9–12 hours), human chorionic gonadotropin (20–30 IU/kg intramuscularly, given twice, 6 hours apart), or Ovaprim (salmon



Fig. 11. Overweight koi; note the widening at the nape of the neck caudal to the skull.

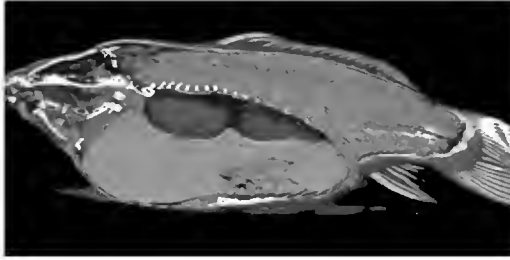


Fig. 12. CT image of a gravid female koi, sagittal section. The large egg mass (roe) is visible below the 2 chambers of the gas bladder. The white spots above the gas bladder are cross sections of the ribs. (Courtesy of Gregory A. Lewbart, MS, VMD, Dipl ACZM, North Carolina State University College of Veterinary Medicine, Raleigh, NC, USA.)

gonadotropin releasing hormone analog + domperidone). Ovaprim is dosed at 0.1–0.5 mL/kg of body weight, given intramuscularly or intracoelomically. Environment and temperature also play a significant role in the reproductive process, and may affect dose and timing. Ovaprim is effective in fish that are within or near their natural spawning season. Ovulation may occur in as little as 4 hours post treatment, so fish should be monitored accordingly.

Radiography, ultrasonography, CT imaging, and laparoscopy are useful in diagnosing abdominal (coelomic) neoplasia. These methods can also provide guidance

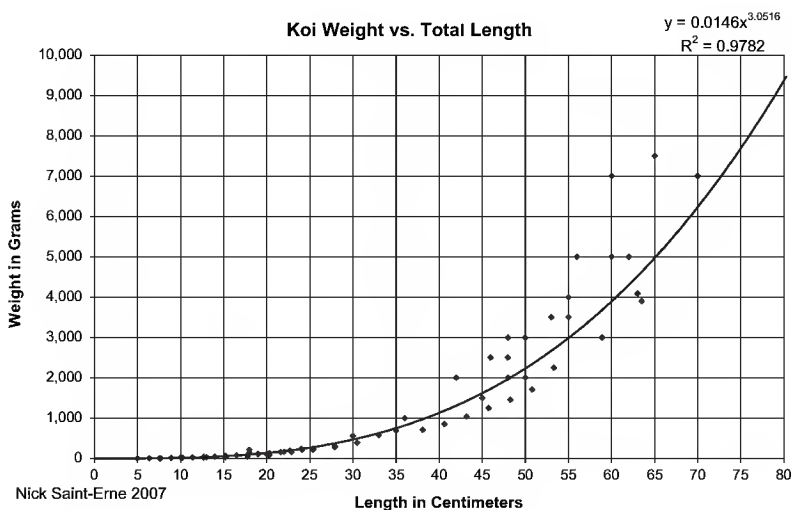


Fig. 13. Weight to length relationship in koi. This chart shows an approximation of the weight (in grams) to length (in centimeters) of koi fish. The black line is an extrapolated average value based on entered data points. Once koi begin to reach sexual maturity at 12 inches (30 cm), there begins to be a difference in weights between the sexes of the same length. Therefore, mature female koi will typically weigh more than the average depicted by the black line, and males will weigh less than the average value for each length. (Modified from data in Saint-Erne N. Advanced Koi Care. Glendale (AZ): Erne Enterprises; 2002. Used with permission.)

for excisional or aspiration biopsy. Excisional biopsy can be an important part of the treatment, as the neoplasm may be removed or debulked, which can provide a significant improvement in the quality of life for the fish.³³ Neoplasms in fish are generally less aggressive and more differentiated than neoplasia in mammals. In fish, a malignant neoplasm often results in local invasion, and metastasis is uncommon.³⁴ Neoplasms progress into space-occupying coelomic masses that can cause compression of the intestines, liver, or gas bladder and local tissue invasion. Necrosis will occur in the larger masses. Fish will survive for months with obvious abdominal distension. Surgical removal is often successful, but early intervention is important to prevent secondary complications (eg, tissue necrosis, intestinal compression, bacterial infection) that will lead to a poor prognosis. Internal neoplasia reported in koi include intestinal adenocarcinoma,³⁵ hepatoma,³⁶ and both male and female gonadal tumors.^{22,37}

Gas (swim) bladder abnormalities occur in koi, which can make them negatively or positively buoyant, both of which require an increased expenditure of energy for the fish to move through the water. One or both of the koi's gas bladder chambers may become fluid filled (blood or water), overinflated with air, underinflated, ruptured, displaced by a coelomic mass, or have an abnormal structure (**Fig. 14**). Floating fish may become sunburned or have damage to the skin because of air exposure. Sinking koi may have a difficult time getting to the surface to eat, and may get abrasions on the ventral skin and pelvic fins from resting on the pond bottom (**Fig. 15**). Koi have physostomous gas bladders—a pneumatic duct connects the caudal chamber of the gas bladder to the pharyngeal esophagus. This location may be source of bacterial introduction into the gas bladder. Bacterial infections of the gas bladder result in

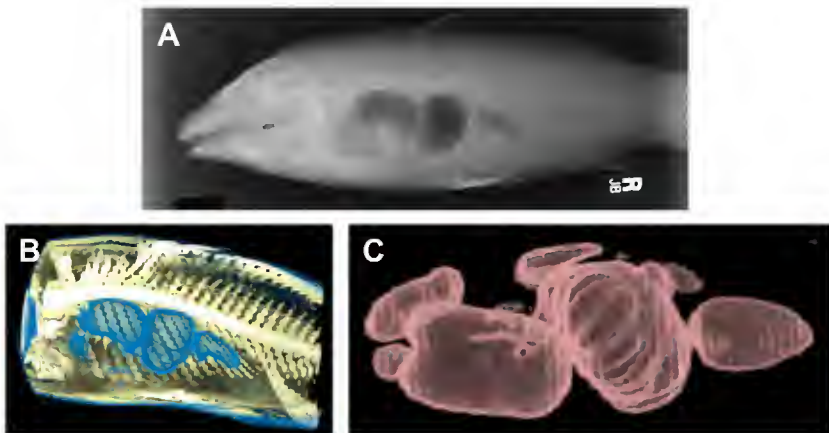


Fig. 14. (A) Lateral radiograph of a koi with an unusual gas pattern. In this radiographic image the cranial gas bladder appears shortened and the caudal gas bladder chamber appears rounded and displaced. There are several other abnormal gaseous objects that could be gas in loops of intestines. (B) CT image of mid body koi skeleton and gas bladder. Derived image, Technique 80 KVP, 100 mA, 2000 ms, slice thickness = 3.00 mm. (C) CT image of koi gas bladder; CT imaging on this same koi shows that the other abnormal gaseous images are superfluous extensions of the gas bladder. Derived image, Technique 80 KVP, 100 mA, 2000 ms, slice thickness = 3.00 mm. (Courtesy of Gregory A. Lewbart, MS, VMD, Dipl ACZM, North Carolina State University College of Veterinary Medicine, Raleigh, NC, USA.)



Fig. 15. Lesions on the ventral surface of a koi from scraping on the bottom of the pond due to a fluid filled gas bladder. (From Saint-Erne N. Infectious diseases. In: Advanced koi care. Glendale (AZ): Erne Enterprises; 2002. p. 68; with permission.)

granulomatous pneumocystitis with infiltration of macrophages, lymphocytes, and multinucleated giant cells.³⁸

Radiographs are helpful in determining the size and position of gas bladders, and whether they are filled with air or fluid. When full of fluid the gas bladder has a homogeneous radiodensity with the viscera below it, and is difficult to delineate. Ultrasound is limited for detailed examination of the gas bladder due to echoes generated by the air in the gas bladder.³⁹ Ultrasonography can ascertain whether the gas bladder contains air or fluid. In some cases excess air causing positive buoyancy is not due to gas bladder disorder but to intestinal tympani (trapped gas in the intestines).

Pneumocystocentesis using a syringe and needle can be done to remove fluid from the gas bladder; some of the aspirated fluid should then be submitted for bacterial culture and sensitivity, and for cytology. To reach the caudal chamber of the gas bladder, use a syringe with a 22-gauge needle (for large koi a needle length of 1.5 in [3.8 cm] is necessary) and place it through the body wall slightly below the lateral line, angled cranially to obliquely pass through the body wall and into the gas bladder. Excess air can also be removed percutaneously through pneumocystocentesis, or the gas bladder can be surgically resected to drain the gas bladder and remove part of it to control overinflation.⁴⁰ Injections of antibiotics can be given directly into the gas bladder for treating internal infections of the gas bladder.

SUMMARY

Standard diagnostic techniques used in a small animal veterinary hospital can easily be applied for use with fish, especially koi. Koi owners are more than willing to have their pets treated by veterinarians interested in aquatic veterinary medicine. Although handling these wet pets takes a little getting used to compared with the other pets routinely seen in a veterinary practice, fish medicine can be very rewarding, challenging, and always interesting for a veterinarian willing to learn and wanting to try new things, especially since there is still much to be learned about the diagnosis and treatment of internal disorders of koi.

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